Intro to Performance Indices

Homework Solution

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Translation Results for the Material for an Oar

Following the translation step of the Ashby Selection Methodology:

- The function of the oar is: a light stiff beam loaded in bending
- The constraints are: length and stiffness
- The objective is: minimize mass
- The free variables are: radius and material choice

Performance Index Derivation

We start by finding an expression for the mass of the oar, which is equal to volume x density. Since the oar is cylindrical, we can use the equation (1) below:

$$m = \pi R^2 L\rho \tag{1}$$

Next, we need an expression for stiffness (2).

$$S = C\frac{EI}{L^3} \tag{2}$$

The second moment of area, I, for our specific configuration is given below.

$$I = \frac{\pi R^4}{4}$$

Inserting the value for I into equation 2 gives us equation 3 below.

$$S = C\frac{E\pi R^4}{4L^3} \tag{3}$$

The free variable found in both our stiffness and mass expression is *radius*, so we will solve equation 3 for r (equation 4).

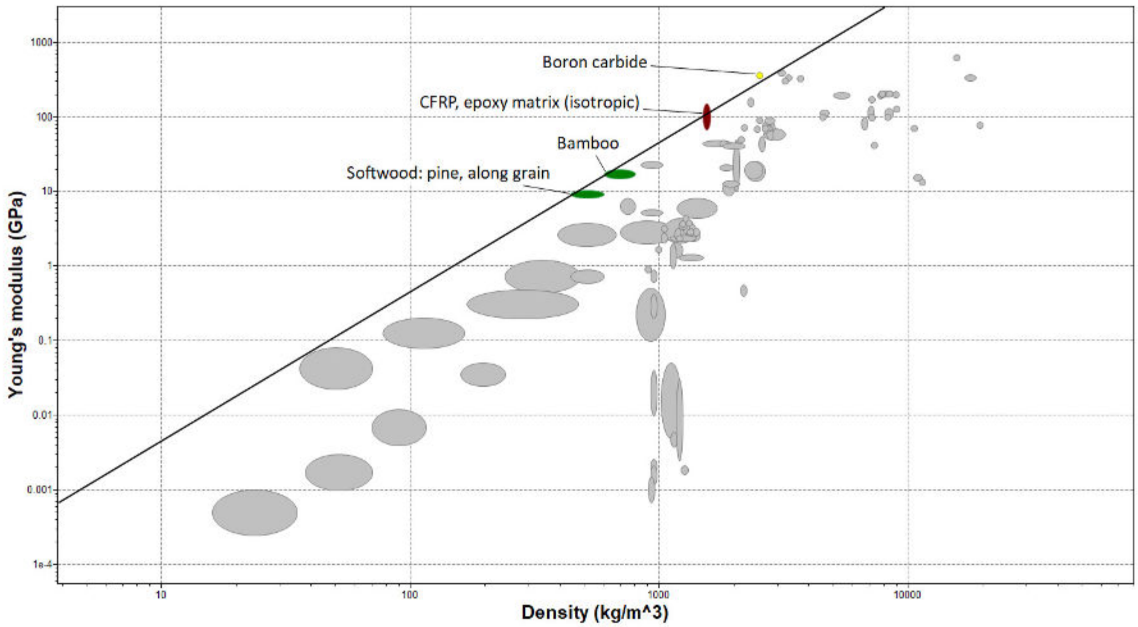
$$R = \left(\frac{4SL^3}{\pi CE}\right)^{1/4} \tag{4}$$

Combining equations 1 and 4 gives us the following expression (equation 5):

$$m = \pi L\rho\left(\left(\frac{4SL^3}{\pi CE}\right)^{1/4}\right)^2 = 2\pi^{1/2}\frac{S^{1/2}L^{5/2}}{C^{1/2}}\frac{\rho}{E^{1/2}} \tag{5}$$

Pulling out the portion related to material properties gives us the performance index: $\boxed{M = \frac{\rho}{E^{1/2}}}$

Selection Charts in Ansys Granta EduPack



Based on this chart, the ideal candidates for oars are carbon fiber composites or wood. While boron carbide is shown, it would be too brittle.